Draft Guidance Document
November 8, 2006

Certification Procedure for Light-Duty and Heavy-Duty Diesel Vehicles Using Selective Catalyst Reduction (SCR) Technologies

Introduction

This document is a draft guidance document discussing the certification of diesel light-duty vehicles and heavy-duty engines using selective catalyst reduction (SCR) technologies. Manufacturers must receive approval for their SCR strategies as part of their application for certification. This draft guidance document outlines our current thinking regarding the criteria that EPA will consider in reviewing manufacturers' applications for certification of diesel light-duty vehicles and heavy-duty engines using SCR systems.

I. Background

On February 10, 2000, EPA published the Tier 2 emission standards for light-duty vehicles and trucks. These standards established common, "fuel neutral" emission requirements for gasoline and diesel vehicles. They also set common standards for all passenger cars, light trucks, and medium-duty passenger vehicles. The Tier 2 standards allow emission averaging and require new vehicles to meet an average NOx emission level of 0.07 grams per mile (g/mi). On January 18, 2001, EPA published a rule setting stringent new requirements for heavy-duty highway engines and vehicles starting in 2007. Manufacturers plan to meet these requirements by optimizing engine designs for low emissions and adding high-efficiency aftertreatment. The diesel engine NOx standard, which is phased-in between model years 2007 and 2010, is 0.20 grams per brake horsepower-hour (g/bhp-hr).

Diesel engine and vehicle manufacturers have examined the use of several different types of NOx reduction technologies in order to meet these requirements. One type of NOx reducing technology, selective catalyst reduction (SCR), is of particular interest to diesel manufacturers because it can achieve as high as 90% NOx conversion efficiencies. An SCR system uses a nitrogen containing reducing agent (usually ammonia or urea) injected into the exhaust gas upstream of the catalyst. The reducing agent needs to be periodically replenished. Without the reducing agent, the efficiency of the SCR catalyst drops to zero and NOx emissions can increase substantially.

The purpose of this letter is to discuss our intended approach for the certification of light-duty and heavy-duty diesel vehicles using SCR systems. The information in this letter reflects our current thinking. We reserve the right to make any necessary changes to our approach for certification of light-duty and heavy-duty diesel vehicles using SCR systems that we deem appropriate.

II. Regulatory Requirements

There are several regulatory requirements that can impact the certification and implementation of SCR for light-duty and heavy-duty vehicles. Two requirements of particular importance are:

40 CFR §86.004-25, §86.094-25 & §86.1834-01 Allowable Maintenance; and
40 CFR §86.094-22 & §86.1833-01 Adjustable Parameters

A. Allowable Maintenance.

Maintenance performed on vehicles, engines, subsystems, or components used to determine exhaust, evaporative, or refueling emission deterioration factors is classified as either emission-related or non-emission-related and as either scheduled or un-scheduled. EPA considers SCR to be emission-related scheduled maintenance. Emission-related scheduled maintenance is considered technologically necessary to ensure in-use compliance with the emission standards. Manufacturers must determine the technological need for maintenance using good engineering judgment. 40 CFR §86.094-25(b)(3) and (4) and §86.1834-01(b)(3) and (4) establish minimum allowable maintenance intervals for various emission-related technologies. EPA determined that emission-related maintenance at intervals shorter than those listed in paragraphs (b)(3) and (4) are not technologically necessary. However, there is a provision in paragraph (b)(7) that allows a manufacturer to request a change to the scheduled maintenance interval, including an interval shorter than prescribed in (b)(3) and (4).

For diesel-cycle light-duty vehicles and light-duty trucks, emission-related maintenance, such as the adjustment, cleaning, repair or replacement of the catalytic converter must occur at 100,000 miles of use and at 100,000 mile intervals thereafter. For diesel-cycle heavy-duty engines, emission-related maintenance can not occur before 100,000 miles of use or before 100,000 mile intervals thereafter for light heavy-duty engines, or before 150,000 mile intervals thereafter for medium and heavy heavy-duty engines. Since the SCR catalyst does not function without the use of a reducing agent, we believe 40 CFR §86.1834-01(b)(4)(ii)(F) and §86.004-25(b)(4)(iii)(F) would apply to the SCR catalyst and all of the associated hardware, including but not limited to, the reducing agent, the reducing agent storage tank, the dosing valve, and all lines and hoses. Because of packaging constraints, many manufacturers have indicated that they would have to equip their vehicles with reducing agent storage tanks with a storage capacity of several gallons resulting in a urea refilling rate of every 6,000-12,000 miles, considerably shorter than the required intervals of 100,000 or 150,000 miles.

In order for EPA to consider a change to the scheduled maintenance interval per paragraph (b)(7), the Administrator must approve a request for approval indicating that the requested change in maintenance schedule is “new,” meaning the maintenance did not exist prior to the 1980 model year, and that the new maintenance interval is technologically necessary. If EPA approves a request for new scheduled maintenance, the Agency must announce in the Federal Register the designation of emission-related maintenance items, along with their identification as critical or non-critical, and the establishment of the technologically necessary maintenance intervals. Unless manufacturers can develop a SCR system that requires the replenishment of urea every 100,000 miles for light-duty and 150,000 miles for heavy-duty, it appears that manufacturers wanting to use SCR technology will have to request a change to scheduled maintenance per 40 CFR §86.1834-01(b)(7) or §86.094-25(b)(7).

B. Adjustable Parameters.

40 CFR §86.094-22 and §86.1833-01 authorize EPA to determine those vehicle or engine parameters that will be subject to adjustment for emissions testing purposes. Paragraphs §86.094-22(e)(1) and §86.1833-01(a)(1) discuss how the Agency determines which parameters are subject to adjustment. Specifically, the paragraphs state "The following parameters may be subject to adjustment: the idle fuel-air mixture parameter on Otto-cycle vehicles; the choke valve action parameter(s) on carbureted, Otto-cycle vehicles (or engines); or any parameter on any vehicle (Otto-cycle or diesel) which is physically capable of being adjusted, may significantly affect emissions, and was not present on the manufacturer's vehicles (or engines) in the previous model year in the same form and function." The Administrator can also determine other parameters to be subject to adjustment under §86.094-22(e)(1)(ii) and §86.1833-01(a)(1)(ii) but must provide notice and lead time

It is important to test a vehicle for emissions over the full range of an adjustable parameter because EPA needs to ensure that the emission performance in-use is as good as at certification. Since some emission components and/or systems can be adjusted, there is a concern that the vehicle could be operated at settings other than the manufacturer's recommended setting possibly resulting in emissions levels that could exceed the emission standards. Paragraphs §86.094-22(e)(2) and §86.1833-01(a)(2) state that a parameter may be determined to be adequately inaccessible or sealed. If a parameter is determined to be adequately inaccessible or sealed, the vehicle will only be emission tested at the actual settings to which the parameter is adjusted during production. Paragraphs §86.094-22(e)(2)(iv) and §86.1833-01(a)(2)(iv) state that in determining the adequacy of a physical limit, stop, seal, or other means used to inhibit adjustment of a parameter not covered by paragraph (a)(2)(i) or (ii) of this section, the following shall be considered: the likelihood that it will be circumvented, removed, or exceeded on in-use vehicles.

Because the NOx efficiency and thus the NOx emissions performance of a SCR system is so dependent on a nitrogen-containing reducing agent, it is critical that a vehicle using SCR never operate without the reducing agent. Most SCR system designs rely on storing reducing agent in a tank located on the vehicle and on the vehicle operator taking responsibility for refilling of that tank with reducing agent. This means that the vehicle operator has to be made aware that reducing agent needs to replaced and that reducing agent is available. Without a mechanism that alerts the vehicle operator that the reducing agent needs to be replaced in their vehicle and without a readily available source of reducing agent, the likelihood that the adjustable parameter will be circumvented or exceeded on in-use vehicles is high. Therefore, we do not believe that a SCR system that requires the vehicle operator to replace the reducing agent can be considered to be adequately inaccessible or sealed.

As a result, it appears to EPA that a SCR system utilizing a reducing agent that needs to be periodically replenished would meet the definition set forth in paragraphs §86.094-

22(e)(1) and §86.1833-01(a)(1) and could be considered an adjustable parameter by the Agency. This means that we have the authority to test a vehicle equipped with SCR with varying levels of reducing agent in the storage tank. This would include an empty tank without any reducing agent. If the vehicle is capable of meeting the NOx standard without any reducing agent, we would not consider the SCR system to be in violation of the standard. However, if the vehicle fails the emissions standards without urea in the tank, we expect that we would deny the certification because the design will be considered unacceptable. If the manufacturer can prove to EPA that they have a SCR system design that will not run out of reducing agent in-use and thus not exceed the emission standards, we may determine that the design is acceptable and approve certification of the vehicle design.

The remainder of this guidance document will discuss acceptance criteria that if met would assure that diesel vehicles or engines that use SCR would meet the Agency's goal of always meeting the emission standards in-use.

III. Adjustable Parameter Acceptance Criteria

We have based our SCR adjustable parameter acceptance criteria on the Agency's goals of ensuring that SCR equipped vehicles control emissions in use and, more specifically, that the reducing agent (assumed to be urea or denoxium) is readily available for and used in these vehicles wherever and whenever they need it. In order to meet these goals, we have divided the acceptance criteria into two categories:

- **Vehicle compliance –**
    - Ensure that vehicles will meet the emission standards in-use (that drivers will not operate the vehicle with empty reducing agent tanks).
- **Reducing agent availability and accessibility –**
    - Ensure that drivers will find SCR-quality reducing agent when they need it.

In addition, while not a specific acceptance criteria, we believe it will be important for manufacturers to educate potential users, service industry representatives, and other stakeholders about SCR systems and their special needs. These efforts would be in addition to the required vehicle labeling and owner's manual information that is already provided.

A. Vehicle Compliance.

The vehicle compliance criteria are divided into five different categories and a manufacturer will have to satisfy all five categories. The categories are as follows:

1. Driver warning system
2. Driver inducement
3. Identification of incorrect reducing agent
4. Tamper resistant design
5. Durable design

1) Driver Warning System. The emissions performance of SCR-equipped vehicles is expressly reliant on having reducing agent in the system. Unlike all other major emission control devices, SCR systems require regular user action to ensure the system is operating properly. It is thus critical that the operator both understands when reducing agent is needed and given sufficient time to find it. A properly designed driver warning system should help address these concerns. Manufacturers would need to use a warning system consisting of visual alarms informing the vehicle operator that reducing agent level is low and must soon be replenished. The warning system would need to escalate in intensity as the reducing agent level approaches empty, culminating in driver notification that cannot be easily defeated or ignored, and cannot be turned off without replenishment of the reducing agent. In order to provide appropriate notice, the visual portion of the warning system would, at a minimum, need to consist of a unique light or message indicating low reducing agent level. The light or message should be located on the dashboard or in a vehicle message center. The warning light or message would need to be different from the "check engine" or "service engine soon" lights used for OBD or other maintenance. The symbol or message used as the warning indicator would need to be clear enough so that the vehicle operator understands that the reducing agent level is low. The vehicle would almost certainly need to also have a separate warning indicator (light or message) which indicates that the reducing agent tank is empty and needs to be refilled. The warning light or message does not initially have to be continuously activated, but we would anticipate that as the reducing agent level approaches empty the illumination of the light or message would escalate, culminating with the light being continuously illuminated or the message continuously broadcast in the message center. All unique SCR system warning lights or messages would need to be approved by EPA. The location of the warning light or message also would need to be approved by EPA.

Manufacturers should also consider an audible component of the warning system. We would expect that as the reducing agent level approaches empty the audible warning system would escalate.

We would also anticipate that the warning system would begin well in advance of the reducing agent tank becoming empty. Depending on the range between reducing agent refills, which is a function of reducing agent storage tank size, reducing agent dosing rate, fuel consumption, and NOx generation, the warning system should begin to activate, at approximately 1,500 miles prior to the reducing agent tank becoming empty for light-duty vehicles. For heavy duty diesel vehicles we understand that factors in addition to those mentioned above affect the time between reducing agent refills. Vehicle weight class and the current load being carried also affect the reducing agent refill intervals, but even given this variability, we believe that the warning system should begin soon enough for the operator to have the opportunity at two refuelings to also refill the reducing agent. The Agency may approve initiation of the warning system at shorter or longer mileages if the manufacturer can demonstrate that a shorter or longer mileage is reasonable.

2) Driver Inducement. The warning systems discussed above are a critical part of the vehicle compliance acceptance criteria. As noted a well designed warning system should be designed to prevent people from operating SCR equipped vehicles without reducing agent. However, we believe an additional, even stronger deterrent will be necessary particularly in the early years of SCR-equipped vehicles. Therefore, some last resort, persuasive measures to induce users to replenish urea will be essential, especially in an empty reducing agent tank situation.

There are a number of methods that could be employed by manufacturers to induce users to replenish the reducing agent before the tank becomes empty. The design or mechanism used will ultimately be up to each manufacturer. While EPA will not prescribe a specific driver inducement design necessary to meet our acceptance criteria, we believe the examples below could satisfy our objective for driver inducement designs. Our objective is quite simple. The driver inducement design must be robust and onerous enough to ensure that users will not operate the vehicle without reducing agent in the vehicle if they ignore or deactivate the warning system. The driver inducement mechanism should not create undue safety concerns

The following are some examples of driver inducement methodologies that we understand manufacturers are analyzing as part of their overall system designs. We believe other options that can meet our overall objectives could be feasible, and we will work with manufacturers as they develop their designs to help address any appropriate certification issues. Certification approval will be based on the overall effectiveness of the deterrents, and compromising vehicle performance is not mandated by EPA.

One group of options focuses on prohibiting vehicle operation if reducing agent is not present. A "No-Engine Restart After Restart Countdown" approach allows a limited number of restarts once the reducing agent range reaches a certain minimal level of miles before the vehicle is unable to restart without the reducing agent tank being replenished. A "No-Start After Refueling" system has the vehicle unable to start after a refueling that has occurred after the reducing agent range drops below a certain level (e.g. the typical range of a single tank of fuel). Lastly, a "Fuel-Lockout" approach has the fuel filler system lock out, preventing the user from being able to refuel the vehicle after the reducing agent range drops below a certain level (e.g. the typical range of a single tank of fuel). The lockout mechanism is robust, for example, not just a locked fuel door that can be pried open. Systems such as these can all operate while some reducing agent remains in the storage tank, thus ensuring emissions controls during all vehicle operation times.

Another way to make sure vehicle operators are adding reducing agent when appropriate is to have vehicle performance degraded in a manner that would be safe but would be onerous enough to discourage the user from operating the vehicle until the reducing agent tank was refilled. The key challenge of this approach is to determine what would constitute an acceptable performance degradation strategy. A degradation approach which maintains vehicle or engine compliance with the emissions requirements helps address this concern. Additionally, use of this approach in combination with another system could be more appropriate.

3) Identification of Incorrect Reducing Agent. It is also imperative that the vehicle design be capable of identifying when the vehicle is operated with the incorrect reducing agent. Our concern is to have the SCR system identify and appropriately respond to a high NOx emissions performance level associated with filling the storage tank with a fluid other than the manufacturer specified reducing agent or with excessively diluted reducing agent. An example of this would be filling the tank with water rather than the specified reducing agent (e.g., urea or denoxium). Possible mechanisms to address and implement this concern include NOx sensors or urea sensors.

Upon identification of an incorrect reducing agent, we believe it is appropriate that the vehicle respond in the same manner as if the vehicle were running low on reducing agent. Thus, once this condition is recognized, the vehicle's warning system would engage for a limited time before engaging the driver inducement (e.g., no-start, fuel lockout, performance degradation, etc.) system. This should allow the operator time to address situations that can be remedied with new fuel or urea while providing the proper incentive to have more serious instances addressed as quickly as possible.

While it is possible that the quality of the reducing agent could vary and a poorer quality reducing agent may not perform as well, we believe that this may be an isolated incident that should be controlled through quality specifications set by industry for the reducing agent rather than requiring the vehicle to identify slight differences in reducing agent quality.

4) Tamper Resistant Design. Manufacturers would have to demonstrate to EPA that their SCR system design is tamper resistant. There are three aspects of a design that we would want to see made tamper resistant:

- Warning System - The visual and audible components of the warning system should be as tamper resistant as possible.
- The Driver Inducement Design - Tamper resistant features will be needed to ensure that the driver inducement system cannot be disabled. The specific requirements will depend on the driver inducement design. For example, the fuel door cannot be pried open for a fuel lockout system or the ability to start the vehicle with no reducing agent for a no-start design.
- The Reducing Agent Doser System - Ensure that the doser cannot be easily deactivated, for example, by disconnecting the electrical connector to the dosing valve.

5) Durable Design. Manufacturers would have to demonstrate to EPA that their SCR system design is durable. This can be accomplished through the annual durability process. For light-duty vehicles, this means a showing of compliance over 120,000 miles, or 150,000 if manufacturers choose to certify to the higher levels. Currently, our light-duty durability requirements require diesel vehicles to undergo whole vehicle testing. Whole vehicle testing should ensure that the SCR catalyst, dosing system, reducing agent storage tank, and lines and hoses are durable. For heavy-duty engines, the useful life is dependent on different classifications. For light heavy-duty diesel engines, the useful life is 110,000 miles. For medium heavy-duty diesel engines, the useful life is 185,000 miles, and for heavy heavy-duty diesel engines, the useful life is 435,000 miles. At this time we anticipate that the SCR durability may involve full vehicle testing due to numerous components in an SCR system, complexity of the system, multiple factors which could impact system performance and the newness of SCR for these mobile applications. Heavy-duty systems that do not involve full vehicle application may need to be addressed differently. It is also possible that variations in reductant quality would need to be addressed.

B. Reducing Agent Availability and Accessibility.

The SCR system requires a reducing agent to function properly. Since vehicle operators will be responsible for refilling the reducing agent tank, it is imperative that the reducing agent be readily available to consumers. Sufficient and convenient availability of the reducing agent is essential to meet these objectives. Sufficient availability requires widespread distribution across the United States. Convenient availability requires the reducing agent to be offered at locations that are easy to find and that would occur during the vehicle operator's normal course of business or operation (e.g., commuting to work, going on vacation, transporting and delivering goods, and operation outside the scope of normal business hours). We believe that this can be best achieved by relying on a combination of reducing agent availability schemes, some of which are discussed below. We believe it is also important to ensure that SCR vehicle operators have opportunities to go beyond a specific OEM network to obtain reducing agent. We understand industry stakeholders are working on such broader availability mechanisms and we encourage these efforts.

Approval criteria for manufacturer's plan for reducing agent availability and accessibility.

As a condition of certification, EPA will review a manufacturer's plan for reducing agent availability and accessibility. It is their responsibility to show that reducing agent will be widely available and readily accessible. EPA will in particular review whether the following procedures are or will be in place:

1. Reducing Agent Available at Dealerships. The manufacturer supplies its dealers with the appropriate reducing agent and guarantees that they will have adequate supplies to ensure that any and all of their customers who need the reducing agent will have immediate access to it through the dealership.

2. Reducing Agent Available at Truckstops. We understand that heavy duty vehicles will routinely refuel and procure reductant at truckstops and similar facilities, rather than at the manufacturer's distributor. Therefore, the heavy duty manufacturer should be able to demonstrate that the reductant will be available at truckstops and other common refueling locations used by the applicable class of heavy duty vehicle.

3. Back-Up Plan. The manufacturer provides a back-up plan, such as a toll-free phone number, that customers can call if they need reducing agent but are unable to obtain it from a dealership or other convenient source. The back-up plan needs to provide quick turn around, such as overnight delivery to the consumer in response to a call to the toll-free number. The cost of the reducing agent to the consumer from the back-up plan should be no more than the cost at a dealership.

Manufacturers should also be able to demonstrate that reducing agent will be available at other commercial outlets. Such outlets will be considered to be, but not limited to, fueling stations, quick oil change facilities, repair and service facilities, and retail outlets (e.g., automotive part stores, such as "NAPA" and "Pep Boys" and large retail stores, such as “Wal-mart”). As the number of diesel vehicles grow, the need for additional outlets will also increase.

C. Education and Outreach for Potential Owners and Service Industry.

SCR relies on the vehicle operator to periodically replenish the vehicle with a reducing agent to ensure the emission control system properly functions. Thus, it is incumbent upon the manufacturer to educate potential owners making them aware of these requirements. We believe manufacturers will need to develop and implement an education plan for prospective vehicle owners, dealership staff, including sales and service personnel, aftermarket service facilities, fueling station staff, quick oil change facilities staff, retail staff, and any other groups or individuals that would be involved in the purchase or sales of SCR equipped vehicles, the service of SCR equipped vehicles, or the sales of reducing agents (such as urea or denoxium) to the public. The following are examples of the types of information EPA anticipate manufacturers would need to provide to demonstrate their public education strategies:

- Explanation as to what an SCR system is, how it works, and why it is important that the reducing agent be periodically replenished.
- What is the reducing agent used (urea or denoxium)? Where does it go in the vehicle?
- Where can consumers purchase the reducing agent? How much will it cost? Is it safe to handle?
- How often does the reducing agent have to be replenished?
- How does the vehicle operator refill the reducing agent tank?
- Explain any potential odors associated with the reducing agent.
- Explain how the warning systems work.
- Explain consequences of ignoring warning system and not replenishing reducing agent.
- Other

The following are examples of where the above information could be provided to the public:

- Owners manual
- Service manual
- Vehicle message center
- Visor
- Fuel door or cap
- Reducing agent storage tank door or cap
- Company web site
- Dealership brochures
- Sales agent and service technician training manuals

III. Additional Certification Issues.

A. Urea Quality Specifications.

Vehicle manufacturers should establish an industry-wide reducing agent quality standard and set specifications. In order to ensure proper operation, manufacturers will need to design SCR systems for the general range of commercially available reducing agents, thus showing the importance of having a defined set of reducing agent specifications. As with other parameters, EPA testing will be based on the same.

It is also important that a common industry-wide reducing agent should be clearly and unambiguously identified, regardless of any brand name that is trademarked by a manufacturer. Similar to motor oils available today, consumers must be easily able to identify that the product they are purchasing can be used for their vehicle regardless of a brand name. An example of this is the American Petroleum Institute (API) "Staburst" logo used for motor oils.

B. Freeze Protection.

The reducing agent should not be adversely affected by extreme climatic conditions, particularly freezing temperatures. Some reducing agents freeze at temperatures that occur seasonally in certain parts of the U.S. Urea, for example, freezes at 11°F. Manufacturers need to either use a reducing agent that will not be affected by low temperatures or design their SCR system to prevent freezing (e.g., use of heater elements in or around the storage tank and heated lines). Manufacturers who choose to use a heated SCR system need to ensure that if the reducing agent has frozen due to an extensive exposure to low temperatures, the reducing agent "thaw" time required before the agent melts enough to be injected into the exhaust system is minimal (e.g., less than 20 minutes).

C. Reducing Agent Refilling Interval.

The reducing agent refilling interval will ultimately be determined by the manufacturer. EPA encourages manufacturers to adopt the longest interval possible. Since the refilling interval falls under allowable maintenance, the process for determining what would be an acceptable refilling interval for the reducing agent will be handled under the provision of 86.1834-01(b)(7) for light duty and §86.094-25(b)(7) for heavy duty, as discussed above.